DELIVERING GIGABIT BANDWIDTH DENSITY FOR HETNET BACKHAUL

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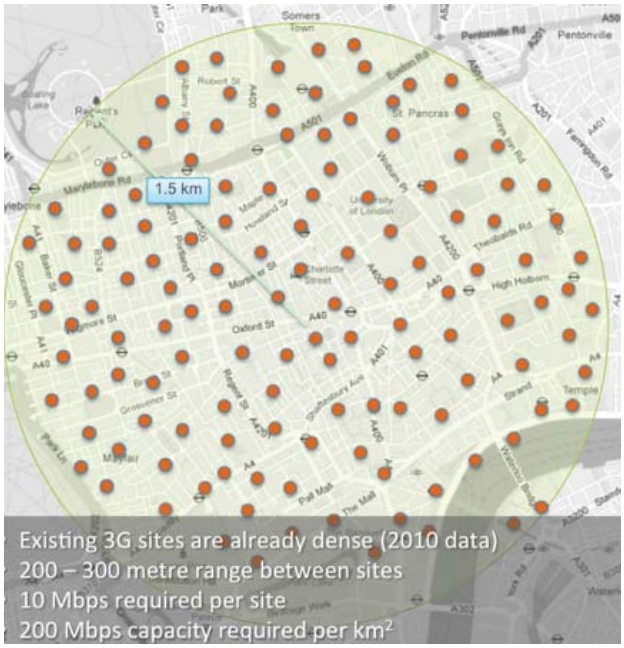
BANDWIDTH DENSITY

What is bandwidth density and why is it important ?

The availability of new services such as mobile video, OTT/multimedia messaging services, mobile cloud computing and the massive proliferation of mobile Apps is fundamentally changing the very fabric of mobile networks. This will lead to a massively dense and complex collection of radio access points in any given area. This collection of access points could be made up of 3G/4G macrocells, wi-fi hot spots and 3G/4G small cells, resulting in an exponential increase in capacity requirements.

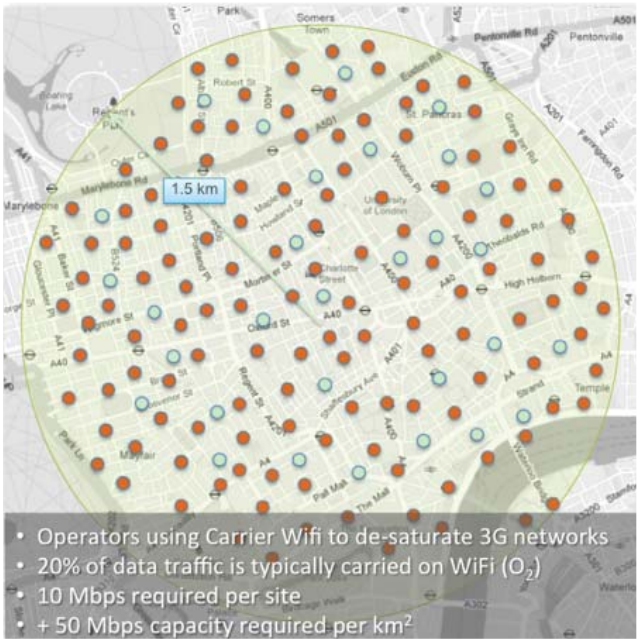
Operators are faced with two fundamental choices: Continue to try and support all these radio access points, including the backhaul with the traditional mix of copper, fibre and in some cases wireless; or simplify the entire zone and "flood" it with bandwidth with a substantially reduced number of backhaul transmission hubs. The entire eco-system is looking at how to increase the amount of bandwidth available to end users, whether we're talking about 3G/4G macro sites, Wi-Fi access points or micro-cells. Each of these heterogeneous layers adds to the capacity requirement on an operator's network.

In a 1.5 km radius, the operator requirement could add up to several gigabits per square kilometre. How does this happen ?



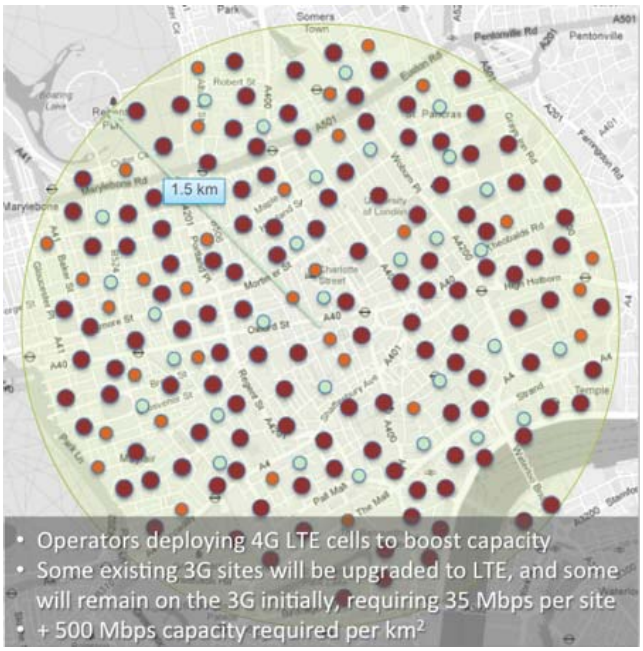
In a typical urban deployment, within a 1.5 km radius (i.e. 7 km²), you are likely to have more than 140 3G cell sites[1]. Taking a conservative assumption that the bandwidth requirement for each of these cells is 10 Mbps, and that a small portion of these cells will be receiving capacity directly from fibre, then it is safe to conclude that the total capacity requirement per square kilometre will be at least 200 Mbps.

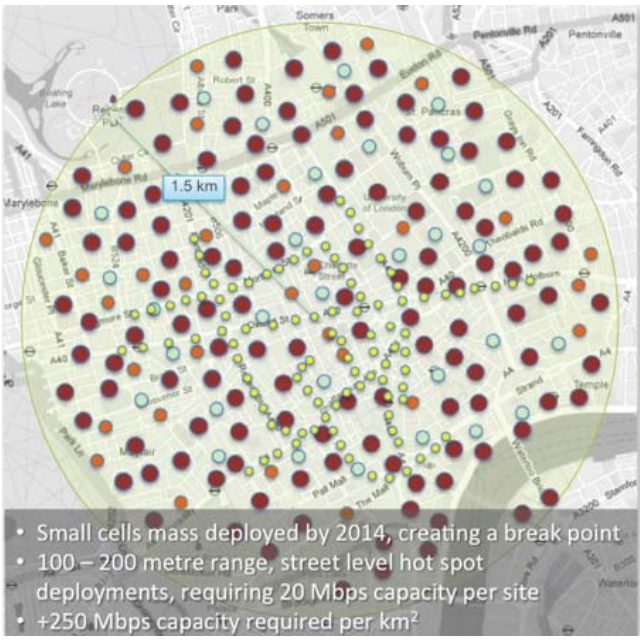
However, a significant number of operators are trying to de-saturate their 3G Networks by adding Wifi offload capabilities. They could be typically adding up to 20 to 30 wifi access points. That adds up to 50 Mbps per square kilometer.



Furthermore, a majority of operators have decided to move to 4G LTE technology and they are chosing to upgrade a portion of their 3G cell sites to 4G e-Node Bs. Not all of the 3G sites are being upgraded at the present time but we can see that currently the demand is around 35 Mbps/ LTE cell site bringing the total additional requirement of 500 Mbps per square kilometer. This is first to provide LTE coverage.

[1] Data on cell site density provided by Ofcom and internal data collected from key mobile operators in the UK.





As LTE demand & LTE adoption by consumers increases, operators will be forced to fill in capacity using 4G LTE small cells. This can add conservatively 20 Mbps per small cell bringing the additional bandwidth requirement to 250 Mbps per square kilometer. This brings at a minimum a requirement of 1 Gbps per square kilometer. If you add to this the ability to provide bandwidth to enterprises, shopping centres, commercial zones and increasing bandwidth requirements per node, then we can easily see how bandwidth requirements could reach several Gbps per square kilometer.

How much each cell consumes can differ across any given areas or point in time. This means that software defined network capabilities are vital to adjust in real time to user demand.

It's very difficult in this kind of environment to plan for the network in advance: the next hot spot could come from anywhere. Bluwan believes it is more important to flood an area with Gigabits per square kilometre rather than to deliver 1 Gbps to each and every cell in this area. Fibre, copper and microwave will cover some of this but a majority of sites will need a new backhaul system. This system must provide scalable capacity for unplanned explosive growth and operators should be able to right size and shape their capacity easily, flexibly, and rapidly in order to remain agile.

Bandwidth where and when you need it

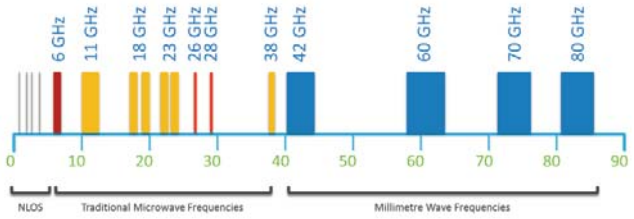
Providing bandwidth density is not just about providing capacity. It is about providing the right capacity in the right places at the right time, to serve all user requirements, and with the flexibility to adapt when needed.

In order to optimise coverage, it is vital to be able to reach those hot spots that need the capacity. In typical microwave systems, being PTP or PMP, line of sight (LoS) technology can be challenging to deploy from an operational perspective. This is because of clutter, and new hot-spots can emerge rapidly and anywhere. This is why backhaul systems need to provide elastic coverage.

Being able to overcome LoS challenges requires a diverse set of antennas and relay capabilities. In this particular example, you could install a 90° sector in the highest spot of the area. However, you would still end up with masked areas that you wouldn't be able to reach, either due to obstruction or to the fact that the sites are at street level. With next generation point to multipoint solutions, an operator is able to install a relay to extend the range and light up masked areas. One can also get LoS to street level access points, using these as relays with a narrow beam antenna to light up busy thoroughfares, connecting with whatever radio access layer required to deliver service to the end user. This implies that solutions need to go beyond just providing 'bandwidth', and focus on ease of deployment, cost efficiency, inherent flexibility, and simplified integration with legacy/existing systems. Software designed networks, multi-beam / beam-forming antennas will become increasingly important to deliver on these key success factors.

BANDWIDTH DENSITY DELIVERY OPTIONS

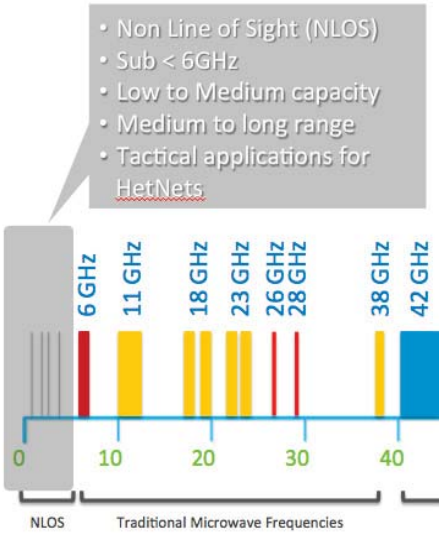
In terms of providing capacity to cell sites and HetNets, there are a number of options currently being discussed as part of the backhaul toolkit. These range from low capacity solutions such as the sub-6 GHz NLOS technologies all the way up to the highly directional millimetre wave PTP technologies in the 60 to 80 GHZ bands. However, how do these solutions stack up in terms of providing bandwidth density, i.e. capacity per square kilometre? Each option needs to be assessed according to key decision criteria such as capacity, interference management, coverage elasticity, ease of installation/management, range and TCO: let's take them one by one.



There are a plethora of options being evaluated for HetNet Backhaul

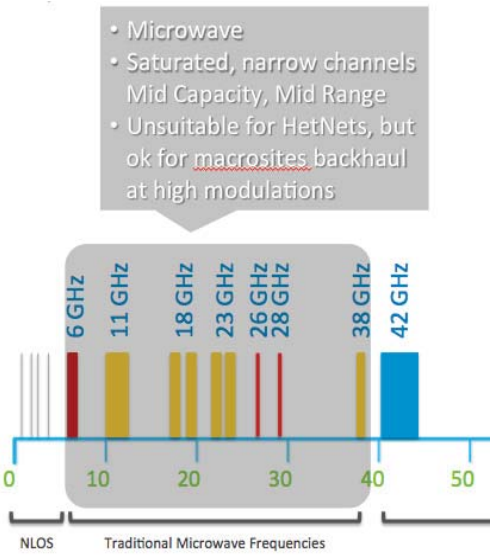
Sub 6 GHz

This category of spectrum has attractive propagation characteristics (medium to long range), making it easy to deploy. It is mainly Non or Near Line of Sight, but interference needs to be carefully managed. As solutions based on this spectrum typically have low capacity, Sub 6 GHz solutions are mainly for tactical deployments, but aren't strategic for delivering scalable bandwidth density for HetNet backhaul.



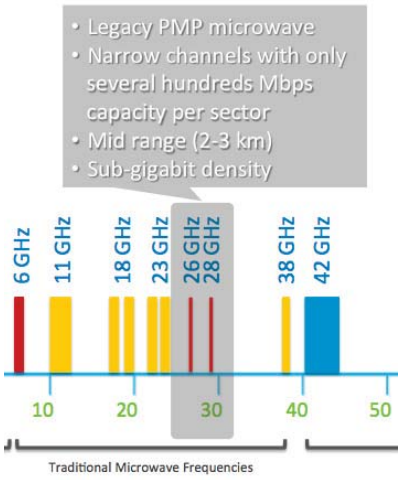
Traditional PTP Microwave (6–38 GHz)

Traditional PTP Microwave suffers from less bandwidth availability, narrower channels making capacity an issue. Higher modulations at 1024 QAM/2048 QAM might improve the capacity, yet this will make the actual planning and deployment of such solutions more complex. Also, these are Point to Point solutions, meaning that in order to deliver Gigabits per square kilometre to hundreds of cells, it would require hundreds of links to be designed, applied for, deployed and maintained. This is difficult to sustain from a TCO perspective. Traditional PTP microwave frequencies are therefore not suitable for HetNets, but can be deployed for macro site backhaul at higher modulations.



Traditional PMP Microwave (24-32 GHz)

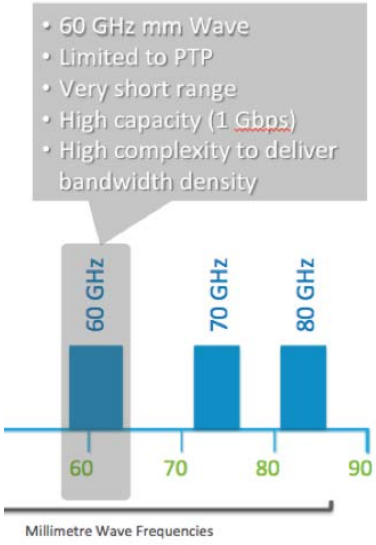
These LMDS (Local Multipoint Distribution Service) solutions have made some great progress in demonstrating small cells applicability due to the efficiency of using a multipoint architecture. However, spectrum limitations make it very hard to achieve gigabits/km2 (narrow channels with only a couple hundred Mbps capacity per sector). End user throughput as well as Quality of Experience is harder to control due to extensive use of statistical multiplexing, and scalability can be challenging, making this option unsuitable for full Heterogeneous Network Backhaul.



V Band (60 GHz)

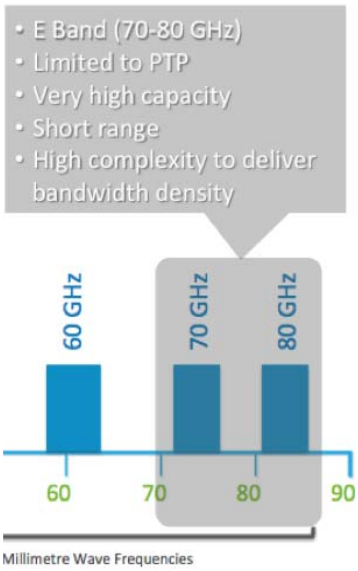
In millimetre wave frequencies, both the 60 and 70 GHz have sizeable amounts of spectrum available for allocation and frequency re-use is often listed as a major advantage due to atmospheric loss. Equipment form factor is smaller than traditional PTP installations and a high capacity can be delivered (up to 1 Gbps).

However, use of this spectrum is limited to PTP; each link has a very short range and large scale operational deployments are challenging. Narrow beam widths for installation make it harder to achieve alignment and complex daisy chained networks are hard to maintain and manage.



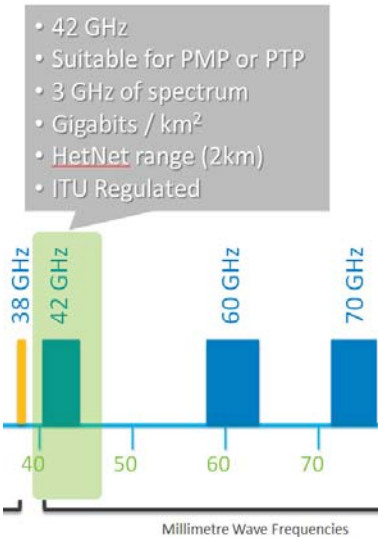
E Band (70-80 GHz)

The E Band has about 10 GHz of spectrum and can deliver very high capacity. However, it is limited to PTP, has a short range and there are problems with licensing regimes. This solution is ideal for macro-site backhaul or enterprise access, but not for HetNet bandwidth density.



Q Band (40.5-43.5 GHz)

The Q band, specifically in the 40.5-43.5 GHz range, has 3 GHz of contiguous spectrum, which has been normalised by the CEPT and ETSI. This spectrum has very attractive properties: it is not affected by oxygen attenuation, unlike the V Band, has large amounts of capacity, and can be deployed in point to multipoint architectures with the perfect range for HetNet backhaul, i.e. up to 1-2.5 km from a base station. The frequency is highly re-usable, like other millimetre wave frequencies. In some ways, the Q band offers the best of point to point millimetre wave in terms of capacity in a point to multipoint configuration, without the capacity constraints of legacy PMP systems. Operators can finally deliver peak point to point site performances but with the efficiency of a multipoint architecture.



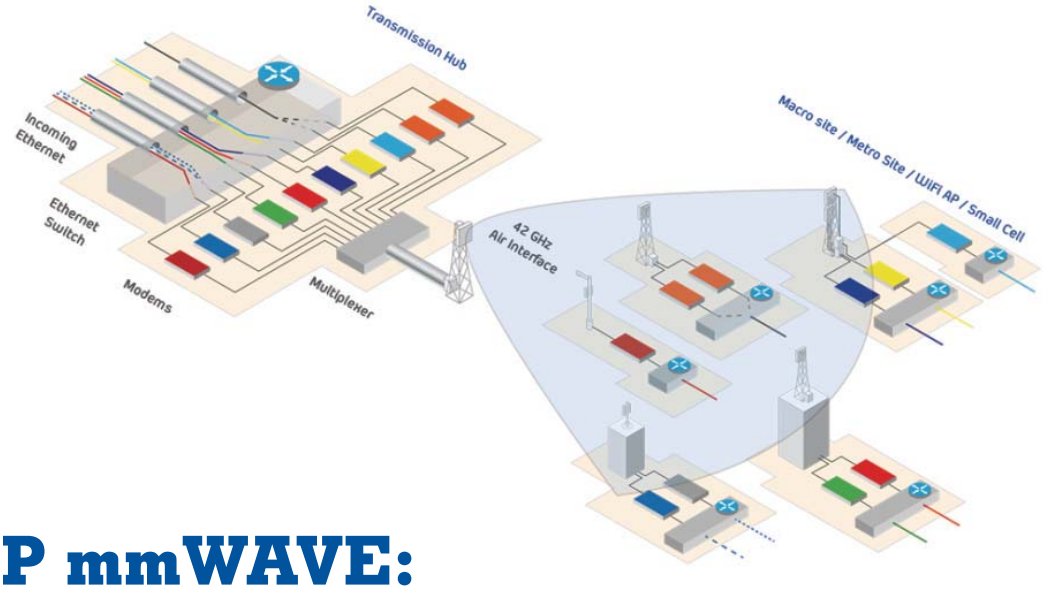
To summarise, operators currently have a diverse toolkit to choose from when trying to deliver on their bandwidth density requirements. The key decision criteria when selecting from this toolkit are Capacity, Interference Management, Coverage Elasticity, Ease of Installation/Management, Range and TCO:

	Capacity > 1Gbps	Interference management	Coverage elasticity	Ease of installation & Management	Range (1-2km)	TCO
Sub 6 Ghz	✗	✗	✓	✓	✓	✓
Legacy PTP	✗	✗	✗	✗	✓	✗
Legacy PMP	✗	✗	✓	✓	✓	✓
PTP mmWave	✓	✓	✗	✗	✓	✗
PMP mmWave	✓	✓	✓	✓	✓	✓

Conclusion

An analysis of the backhaul toolkit shows that even if NLOS systems are convenient and point to multipoint systems are operationally efficient, they do not fulfil the actual surface capacity requirements for HetNet backhaul. Bandwidth density is about coverage AND capacity, not delivering on one and failing on the other.

Bluwan has identified the "gold" spectrum giving the ability to attack this challenge from both angles: the 42 GHz Q Band spectrum (40.5 - 43.5 GHz). It has excellent properties: 3 GHz of contiguous and available spectrum in most CEPT/ETSI markets, physical characteristics making ranges of 1-2 km possible, with multi gigabits capacity per square kilometre. Frequency re-use can also be applied as long as radios and antennas are properly designed. It is possible to deploy either point to point, or multipoint, giving operators a fair bit of flexibility in their network design.



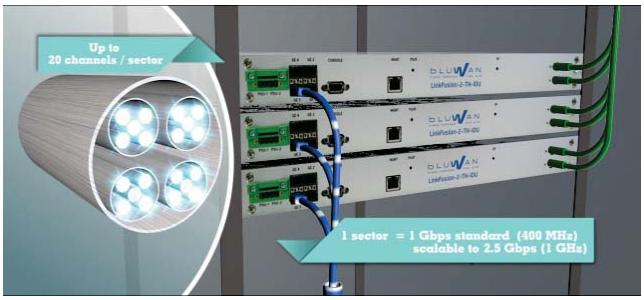
PMP mmWAVE: A NATURAL EVOLUTION

Bluwan created LinkFusion, a backhaul system which delivers up to 10 Gbps on a standard 4 sector point to multipoint configuration, using 42 GHz spectrum.
This is about 1.5 Gbps/square kilometre. Bluwan can increase this capacity further through increased sectorisation and in the future by using MIMO and next generation chipsets.

Using a PMP architecture allows operators to keep the quantity of equipment low, reduce install, alignment, rental, and maintenance costs, as well as accelerate the time to market for the delivery of services. Only one backhaul system is necessary for 3G, 4G, Wi-Fi, small cells and enterprise access.

Architecture

Delivering gigabit bandwidth density means that a significant amount of flexibility needs to be provided to operators in terms of provisioning the end point. The LinkFusion architecture allows operators to deploy either in Point to Point mode or Point to Multipoint Mode.
Bluwan has a 1 GHz wide radio unit operating in 3 sub-bands. Each radio can actually transport up to 20 channels. Each channel delivers up to 125 Mbps, hence it can scale up to 2.5 Gbps on a single ODU. The standard IDU is an 8 channel IDU that can deliver 1 Gbps. Each IDU is stackable so that operators can provide more capacity without replacing the outdoor kit.



PMP mmWave systems such as Bluwan's LinkFusion deliver up to 10 Gbps on a single Hub

LinkFusion also allows operators to allocate a single channel per end point, in effect "dedicating" 125 Mbps TDD bandwidth to the terminal. If the end point capacity requirement is higher, LinkFusion can "bond" 2 channels together to deliver up to 250 Mbps per end point. This mode is called "PTP Peak Performance".

PTP Peak Performance:

In this instance, a single channel is dedicated to the end terminal in the same manner as a traditional PTP 1+0 connections and delivers 125Mbps of capacity. The difference being that LinkFusion can share up to 20 x 40 MHz channels into a single aggregation radio and therefore offers a total capacity of 2.5 Gbps.

PTP Peak Performance should be selected when bandwidth requirements to the site are high, typically for a larger base station (4G LTE, enterprise access, Multiple Dwelling Units, or triple play services).

PMP Shared Performance:

Bluwan also provides another mode called "PMP Shared Performance": it allows up to 4 LinkFusion remote terminals, or NTEs to share a single channel.

In this method, the single channel can be shared between up to 4 terminals, each receiving a guaranteed capacity of 30Mbps. Therefore, it is possible to serve 80 terminals with a CIR of 30 Mbps of guaranteed capacity using the same 20 x 40MHz channels all terminating on a single sector outdoor unit. A single IDU, with 400 MHz of spectrum, would be able to hit 32 terminals with 30Mbps of guaranteed capacity.

IDU's can be stacked to increase spectrum usage to consume the entire bandwidth of the radio (1 GHz).

Operators should use PMP Shared Performance when providing lower bandwidth to each remote terminal, such as for small cells, mass market triple play customers, or small medium businesses.

Each channel can independently be configured in 'Peak' or 'Shared' mode using a software defined network layer, making the solution very flexible to dynamically manage different network usage scenarios.

DELIVERING GIGABIT BANDWIDTH DENSITY IN PRACTICE

Operator case study

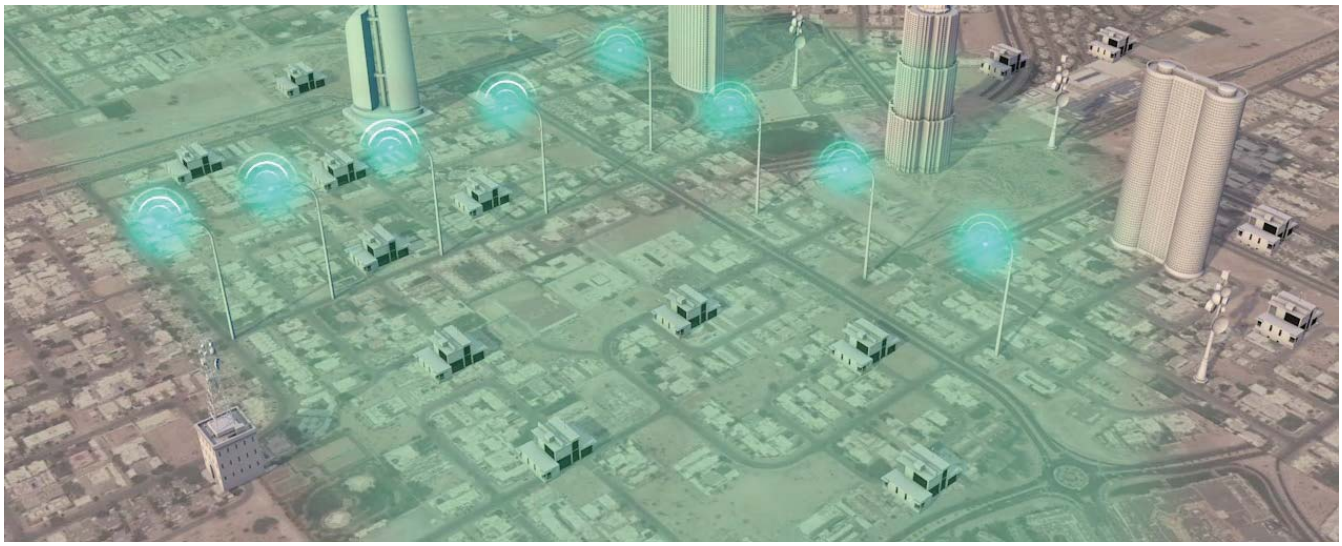
Here's an example in the UAE where Bluwan is working with some operators to test the capacity of the LinkFusion solution, its relay capabilities, and delivering bandwidth to a combination of end units: 3G/4G Mobile backhaul as well as fixed wireless access to households not connected to the customer's fibre network.

It is a 2-sector configuration trial setup:

The first sector delivers 1 Gbps and provides bandwidth to 3 end points. One of these end points is actually a relay point to overcome a Line of Sight obstruction. The relays can be 90 degrees, 45, 22 or even near point to point links at 6 degrees.

The 2nd sector demonstrates the ability to provide 250 Mbps of dedicated bandwidth to a single site, but also proves the low latency nature of the multipoint environment, by also configuring an extra terminal in the sector.

This trial was done in harsh conditions, in the heart of summer with rooftop temperatures in excess of 50 degrees Celsius. The primary goal of the pilot was to consolidate multiple end point capacity requirements and aggregate these to a single hub point. This allowed the operator to demonstrate that a point to multipoint system such as Bluwan's LinkFusion is capable of servicing multiple sites with very high bandwidth across multiple service layers.



Using Bluwan's LinkFusion solution, this operator can now deliver sufficient bandwidth density to provide residential access, small cell backhaul and LTE backhaul.

Results of the trial

The results of the trial demonstrated different throughputs at different modulations, with multiple terminals connected to a single sector, each receiving speeds in excess of 100 Mbps.

The success of this leads to a plethora of options moving forward. From a single system, this operator will be able to provide mass market triple play services in areas where it currently doesn't have a dominant fibre footprint, improve mobile broadband user experience by providing fast backhaul to small cells and macro-sites, and also deliver services to small medium businesses.

Site Reference	Site Type	Beamwidth	Distance (km)	Modulation	Throughput (PTP)
TH1	TH	90°		-	1 Gbps
TH2	TH	90°		-	1 Gbps
Site 1	NTE-1	6°	468m	64QAM 3/4	117 Mbps
Site 3	NTE-1	6°	85m	64QAM 5/6	125 Mbps
Site 4	NTE-1	6°	631m	64QAM 2/3	104 Mbps
Site 5	NTE-1	6°	503m	64QAM 3/4	117 Mbps

Field performance measures

This particular operator actually needs to provide 90% of the country with more than 3 terabits of capacity. There is only a limited budget for additional fibre deployment, so providing a high bandwidth density solution is the only way to deliver on this requirement. E band links would typically be used to provide "Wireless Gigabit Bridges" from the fibre to backhaul the Bluwan LinkFusion system if fibre PoPs are not available.

The business case will cover LTE, small cells, enterprise, and access; in effect, using the LinkFusion system's scalable bandwidth density to flood the area with capacity and accelerate the ROI by making sure that the capacity deployed in the coverage area is consumed effectively.

CONCLUSION

It is clear that the future of backhaul is evolving. Just as demand for macro-cell backhaul is decelerating, the need to provide high capacity, cost efficient, scalable and adaptable backhaul systems to cater for ever increasing bandwidth density requirements is becoming increasingly important.

Bluwan's LinkFusion multi-gigabit wireless transmission system allows service providers to solve the bandwidth density challenge by dramatically increasing the coverage and capacity of existing networks. The technology developed by Bluwan is the culmination of several years of R&D performed in collaboration with the Thales Group in the defence and aerospace markets.

Bluwan has developed the 2nd Generation of Carrier Grade Point to Multipoint (PMP) microwave equipment in the 42GHz band to meet the capacity requirements for next generation networks in a PMP configuration, ensuring substantial year-on-year Opex savings.

Bluwan's LinkFusion can scale to deliver multi gigabit sector capacity by combining up to 20 x 40 MHz channels into a single outdoor sector radio, thus delivering a sector capacity up to 2.5 Gbps, allowing operators to deliver 125 Mbps or 250 Mbps IP peak performance connectivity for multi-layered heterogeneous networks including 3G/4G macro sites, small cells, or carrier WiFi backhaul, as well as providing very high throughputs to high value triple play or enterprise customers on the same platform and maximising the ROI of the Hub site infrastructure cost. Up to two channels can be dedicated to a Network Terminating Equipment (NTE), or a single channel can be shared across multiple NTEs for lower throughput requirements.

For the first time, operators are able to deploy Multipoint Microwave technology and service peak PTP performance at a substantially lower Capex and Opex than FTTx solutions.

Bluwan's 42 GHz LinkFusion Millimetre Wave (mmW) Point-to-Multipoint backhaul system is ideally suited for HetNet backhaul. With 10 Gbps per 4 sector transmission hub, MNOs can easily address their bandwidth density requirements. For the first time, using Bluwan's compact 125 Mbps and 250 Mbps Network Terminating Equipment (NTE), MNOs can deliver peak Point-to-Point performance combined with the TCO benefits of a Point-to-Multipoint solution. Bluwan's LinkFusion Relay solution enables operators to overcome LoS (Line-of-Sight) hazards and easily deploy coverage to black-spots and street canyons.

Beyond the traditional cost reduction associated with the usage of Point-to-Multipoint, Bluwan's LinkFusion system enables operators to simply light up a coverage area by deploying a capacity pool, and deploy end-points or relays as required to provide total coverage. Operators no longer need to spend large amounts of time designing and re-designing complex mesh or daisy-chained network topologies. Due to LinkFusion's inherent high capacity and bandwidth pooling capabilities, backhaul service providers or MNOs engaged in network sharing alliances can deliver multi-dimensional QoS profiles for multiple operators across multiple sites, enabling them to easily assign bandwidth pools for backhaul and RAN sharing.

To summarise Bluwan's LinkFusion core capabilities:

- PMP Dynamic TDD System
- Operates in the licensed, uncongested and inexpensive 40.5 – 43.5 GHz Q-band spectrum
- 10 Gbps scalable Hub Capacity
- 16x the bandwidth of traditional PMP
- Zero-touch provisioning & Self Optimising Network
- 125 Mbps and 250 Mbps Peak Performance
- Dedicated bandwidth for high capacity multi-technology small cells, macro-sites, or enterprise
- Capacity sharing for lower bandwidth small cells, Wi-Fi Access Points, and small medium enterprises

For more information on LinkFusion, please contact sales@bluwan.com and download our datasheet from www.bluwan.com.

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